Original Scientific Article

The Yield and Challenges of Charitable State-Wide Photoscreening

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ABSTRACT: ***Introduction:*** State-wide cooperative programs for pediatric vision screening utilizing the MTI photoscreener and centralized interpretation were established in Alaska (The Alaska Blind Child Discovery, ABCD) and in Tennessee (Tennessee Lions Outreach).

Methods: Details of setup, implementation and interpretation of the state-wide MTI photoscreening programs are compared through 2002. The absolute numbers of children screened and the breakdown in interpretation categories are presented.

Results: ABCD screened 14,000 children while Tennessee Lions screened 100,800. Similarities between ABCD and Tennessee programs were funded by Lions Clubs and other charitable and public health organizations, community screening and each had coordinated centralized image interpretation and notification. The programs differed by clinic focus (Tennessee Lions organized pre-schools while ABCD used village and community health fairs and schools), parent notification (Tennessee Lions communicated through pre-schools and ABCD mailed directly to parents), and image interpretation (Tennessee used VOIC age-based and pupil-size crescents while ABCD used "delta-center crescent"). Predictive value positive was 73% for Tennessee and 89% for ABCD. Tennessee achieved better followup on referrals after a specific coordinator was employed. Image interpretation breakdown for ABCD: Tennessee Lions Outreach were anisometropia (29%:34%), high hyperopia (33%:16%), astigmatism (18%:30%), strabismus (7%:15%), myopia (5%:2%), cataract (0.7%:0.2%). Two state-wide programs detected 3216 amblyopic children at a charity borne-cost of $1.5 million. If the parents persisted with appropriate amblyopia therapy, the expected societal value was estimated at $17 million. Lacking societal mandate and funding, these concerted charitable efforts only achieved a community penetration rate of 10% to 14%.

Conclusion: National adoption of preschool vision screening by a method with similar or even better validity and cost effectiveness as MTI photoscreening, ideally in the pediatric medical home, is warranted.

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INTRODUCTION and BACKGROUND

The U.S. Preventive Service Task Force (Evidenced-Based Medicine) endorses pediatric vision screening (1). Amblyopia is a blinding condition of childhood that qualifies for public health detection by screening (2), since it has sufficient prevalence (3% to 4%), produces a lifetime visual deficit, has a latent period (the first decade) and can be detected in time for effective therapy to be implemented (3).

The American Academy of Pediatrics (AAP) supports guidelines of screening tests to detect functional or organic amblyopia and/or ocular conditions that predispose a child to functional amblyopia (media opacity, strabismus or significant refractive error) (4,5).

One of the most important components of the AAP guidelines is visual acuity testing at age 3 to 4 years (5). Such acuity screening was adopted because similar testing, by highly skilled public health nurses or orthoptists in Europe, detected affected children this way and, combined with thorough therapy, was able to reduce the prevalence of blindness due to functional amblyopia (6,7). However, the way that acuity testing has been done in these European studies may be more reliable for this purpose than conventional acuity screening in a busy pediatric practice in America (8).

Photoscreening is a technique that can estimate binocular alignment and refraction by analysis of the reflected retinal image in both pupils (9,10). Photoscreening is particularly useful in detecting high latent or unequal amounts of hyperopia in pre-literate children who do not have obvious strabismus.

One of the commercially available photoscreeners developed by Howard Freedman (11) employing rapidly developed Polaroid film is called the MTI photoscreener (Medical Technology Inc, Lancaster, PA). The MTI has had very extensive validation (12,13) contributing to the guarded 2002 endorsement by AAP for its use in pediatric screening (14). Since then, objective testing of this photoscreening system (by remote autorefraction) has established validation similar to monocular patched visual acuity testing in preschoolers (VIPS, 2004 #1336).

While some alternative and emerging (Arnold, 2006 #1776) photoscreeners employ digital technology interpretation of photos by on site (15) or remote (16) interpretation, the MTI system is shipped supplied with a manual of published images constituting refer or non-refer suggestions allowing the primary interpretation by the screener. This has led to several publications, challenging the merit of MTI photoscreening, based on non-uniform interpretation (17-20). This, however, allowed and enabled our programs to develop our own improvements in interpretation.

We report herewith our experiences implementing statewide volunteer MTI photoscreening programs with evolved, centralized interpretation centers.

METHODS

THE ALASKA EXPERIENCE

The Alaska Blind Child Discovery (ABCD; www.abcd-vision.org) program started in late 1995 with acquisition of the first of 18 Alaska MTI cameras. With no clear reimbursement and no uniform guidelines, pediatricians were reluctant to purchase MTI screeners themselves, but public health nurses and charitable organizations (most notably the District 49A Lions Clubs) readily adopted this technology. Photoscreeners were distributed out of regional hubs covering towns or several villages. A coordinating center was set up in a multi-subspecialty private eye clinic using an orthoptist as coordinator and the pediatric ophthalmologist (RWA) and his optometrist partner as image readers. The ABCD program drafted paperwork for individual child records, clinic reports and patient notification and therefore received approval from the Institutional Review Board of Providence Alaska Medical Center.

ABCD initially emphasized photoscreening children aged 1 and 4 years but later included children up to first grade. Public health nurses photoscreened children from remote Alaskan villages as a part of scheduled well child visits. Charitable organizations photoscreened children in a few day care centers but emphasized advertised events such as the Alaska State Fair (21) and later also including children in some kindergarten classes.

The initial validation data suggested a large number of false positives (22). At the same time, a photoscreener was continuously used in the offices of the interpreters for comparative feedback as well as application on known cases of amblyopia under both good and less than ideal focus and alignment in order to further refine interpretive criteria. Certain other serious eye conditions were observed in MTI image interpretations (23) prompting even more carefully guided interpretation. A simplified criteria called "delta center crescent" for the regular photoscreen [red light reflection] crescent measurement was devised for both the MTI and for other types of photoscreeners (24,25).

The ABCD program was initially presented publically at state meetings of Alaska's optometrists and ophthalmologists. Parents of children with "positive" (for pathology) screening interpretations were notified by mail that they should pursue a confirmatory complete eye exam, with cycloplegic refraction, from their nearest convenient eye doctor. Those eye doctors consulted were encouraged to notify the ABCD coordinating center of the results of the confirmatory exam. Unfortunately, ABCD had a low rate of followup on the "positive" screened children. To remedy this problem, several followup mailings were sent to those parents, inviting them to return for free confirmatory exams, paid for by the coordinating center or the Lions Clubs.

Validity measurements are incomplete because, unlike the original MTI validation study (12), "normal" interpretation children were not specifically recruited

back for followup confirmatory exams. We did employ specific criteria on confirmatory exams to define a "true positive" finding (26).

THE TENNESSEE EXPERIENCE

This photoscreening program began September 1997 with support from the Lions Club. The statewide program was coordinated through the Vanderbilt University Ophthalmic Image Center (VOIC) and is called the Tennessee Lions Outreach. Lions clubs volunteers were carefully trained for this. They conducted clinics in day care centers, preschools and organized "mothers days out". Three individuals who had extensive experience interpreting retinal images for diabetic retinopathy studies were trained to interpret the MTI images with close oversight by the second author (SPD). Results were returned to the child care centers allowing the staff of these centers to directly inform parents. Optometrists and ophthalmologists in Tennessee were contacted by the program center and recruited to volunteer to perform confirmatory exams. All participating doctors were advised to perform a comprehensive eye exam including cycloplegic refraction and to report findings to the VOIC. Eventually, when close to half of the referred children did not yet have confirmatory eye exams, an additional person was hired by the Vanderbilt Eye Center to coordinate followup of referred children.

With initial interpretations guided by the supplied MTI users' manual, it soon became clear that the "false positive" rate was too high. To remedy this, the relationship between photoscreen crescent size and pupil size was introduced, and referral criteria refined (27,28).

RESULTS

Data on image interpretations are given in Table I, below. Comparative data for the Tennessee and Alaska statewide charitable photoscreening programs are given in Table II, overleaf ->.

The "predictive value positive" varied by followup

Table I: RESULTS of Charitable Eye Photoscreening for Amblyopia and Eye and Vision Defects in 114,827 Children in Alaska and Tennessee: Distribution of Causes and Pathology of "Positive Tests"

SUSPECTED CONDITION	ALASKA (ABCD)	TENNESSEE (VOIC)
ANISOMETROPIA	232 (28.6%)	1164 (34.2%)
HIGH HYPEROPIA	266 (32.8%)	554 (16.3%)
ASTIGMATISM	148 (18.3%)	1015 (29.8%)
STRABISMUS	58 (7.1%)	524 (15.4%)
MYOPIA	45 (5.5%)	67 (2.0%)
CATARACT	6 (0.7%)	5 (0.2%)
OTHER	80 (9.9%)	78 (2.3%)

Legend for Table : VOIC and ABCD simultaneously developed different photoscreen crescent criteria to improve upon the published manufacturer guidelines. Suspected condition is a sub-categorization of a positive photoscreen interpretation usually corresponding to the confirmatory exam finding, i.e a photoscreen with horizontal and vertical hyperopic crescent right eye but normal focus left eye associated with a cycloplegic straight-eye follow-up with more than 1.5 diopters spherical equivalent hyperopia right eye. Some "suspected condition" astigmatism referrals had spherical high (>3.50 diopters) hyperopia despite only one (horizontal) photoscreen images containing the hyperopic crescent presumably due to variable accommodation for the two flash images. "Other" included Brückner anomaly, pupil differences, ptosis, and other media opacities.

Table II: RESULTS of Charitable Eye Photoscreening for Amblyopia and Eye and Vision Defects in 114,827 Children in Alaska and Tennessee: A Comparison of Characteristics and Statistics for the Two programs

	TENNESSEE LIONS OUTREACH, Tennessee	ABCD, Alaska
State Population (1-5yrs)	5.8 million (384,000)	625,000 (50,000)
Volunteers	Lions	Lions, PHNs, ILPs
Screen Training	Formal 3.5 hour sessions	Video, "apprentice"
MTI Cameras	35	18
Ophthal /PDI / optoms	297/9/720	25/2/90
First screened	September 1997	February 1996
Learning curve: yrs/kids	1.0/5000	1.5/1000
Photos per child	1.46	1.16
Target	Daycares, preschool	Villages, fairs, ILP, clinics
Target age	12-72 months	1-5 years
Notification	Daycares	Parent mailing plus clinic
Confirmatory Exams	Prevolunteered MD/ODs	Pre-notified "convenient" MD/OD
Follow up	Full-time paid: phone	Merge mailings, free exams
Interpretation/coordinators	VOIC Reading Center/3 trained/3	Ophthalmologist / optom/1
Criteria	Pupil size crescent[27, 28]	Delta center crescent [24, 25]
Total screened	100,827	14,000
Percent "refer"	4.6%	5.8%
Percent "normal"	92.3%	93.8%

Table II continued on next page

Table II *(cont'd)*: RESULTS of Charitable Eye Photoscreening Amblyopia, Eye & Vision in 114,827 Children in Alaska and Tennessee: A Comparison of Characteristics and Statistics for the Two programs

	TENNESSEE LIONS OUTREACH, Tennessee	ABCD, Alaska
Percent "inconclusive"	3.1%	0.4%
Positive Predictive Value	73.2%	89%
Penetration of kids 1-5	10%	14%
Follow-up of "refers"	72%	49%
Program Cost	$1,400,000	$150,000
Incremental Cost	$4[41]	$10.80[31]
"Blind" Children detected	2494	722
Potential "Blind" costs saved[42]	$13.2 M	$3.8 M

LEGEND FOR TABLE The Tennessee Lions houses the VOIC (Vanderbilt Ophthalmic Imaging Center), The "Learning Curve" was a period of feedback photoscreen image interpretation to achieve a predictive value positive (PPV) greater than 50%. The incremental costs are the ongoing cost of film, camera maintenance, clinic paperwork, parent and clinic notification (ABCD directly mailed color brochures and photocopies while VOIC notified the screening clinics). Incremental costs do not cover start-up program costs. "Blind" indicates children with vision impairment of one or both eyes.

doctor training: for Vanderbilt pediatric ophthalmologists PPV was 74% whereas for general ophthalmologists and general optometrists PPV was only 46%. For ABCD, in part, due to the high cost of confirmatory exams for rural screening in Alaska, ABCD sought to reduce its rate of "uninterpretable" results and attained a high PPV when its most experienced volunteer photographers did the screening (21). Since feedback on confirmatory exam data on non-referred children was lacking, comprehensive screening validation (i.e., calculation of sensitivity and specificity) could not be completed (21). On the other hand, if these preliterate objective screenings had a high "false negative" rate five years ago, then one might expect a large number of school aged visual acuity tests to reveal such a deficiency; fortunately, neither VOIC or ABCD have documented such a problem.

The percents of goal-aged children screened over the reported statewide charitable efforts were 10% for Tennessee and 14% for Alaska.

DISCUSSION

Two independent statewide, charitable programs with internally developed, feedback image interpretation achieved remarkably similar yields and predictive values but failed to penetrate the populations of communities more than 15%.

The American Academies of Pediatrics and Ophthalmology remain dedicated to providing vision screening of every child. However, it seems not every American child enjoys the benefit of consistent preventative care in a pediatric "Medical Home" that conscientiously follows the AAP vision screening guidelines. In fact only a small minority seem to. This is prompting efforts by organized optometry in some states to "replace" vision screening with mandated comprehensive eye examinations (29).

Vision screening has a significant societal cost benefit compared to mandated comprehensive eye

examinations (30,31). (Our personal contact with Alan White, PhD, from the research group Abt Associates confirmed that the QALY (Quality Adjusted Life Years) cost for usual care was $18,390, while a comprehensive pre-K eye examination yielded QALY cost of $12,985. But his calculations determine that concerted vision screening yielded the best, lowest QALY cost of only $5680, (less than half of the second option and less than one third of the first option). In what location and by whom should concerted pediatric vision screening be done: by public health nurses in community clinics, or by schools, or in the family pediatric clinics? This report chronicles our experiences with charitable statewide lay vision screening.

One of the successes of each program was improved validity through screening skill and interpreter experience. ABCD and the VOIC centers independently discovered initial high false positive interpretation rates, but then achieved a much higher level of validity through feedback between screeners, interpreters and confirmatory examination results. The primary investigators sought a cost-effective higher specificity level than some internally interpreted systems. This may be due to corporate liability and financial support playing a greater role in determining pass-fail criteria on a receiver-operative characteristic (ROC) curve (15). Both programs detected a large number of amblyopic children in each state. Volunteers who continued to perform screening after more than one clinic achieved a high readability rate with feedback on image quality.

The failures of these programs primarily center around low and incomplete penetrance of screening in communities, and low and incomplete followup on referred children. ABCD achieved its highest penetration in small bush communities where public health nurses were able to individually contact almost all children in each community and where the Lions Club volunteer screeners were allowed to screen public school kindergarten children in their communities, (at an age older than the initial goal screening age). The Tennessee model achieved high penetrance in communities with many children in child care centers; however, many children do not attend these centers at the target screening age.

In neither Alaska nor Tennessee, did the community penetration of photoscreening come close to the level of statetewide immunization rates, despite extensive volunteer effort and coordinated Lions Club promotion, Since photoscreening, per se, has not yet been definitively endorsed by the American Academy of Pediatric Guidelines (32), the pediatricians and primary pediatric care givers were not routinely advising parents to have their young children photoscreened during our period of investigation. Such endorsement would undoubtedly improve matters.

Since the inception of the Alaska Blind Child Discovery and the Tennessee Lions Outreach statewide programs, other local photoscreening programs have emerged (43). Starting with the initial user's manual that accompanied the MTI cameras, each of our centers did extensive refinement of image interpretation with feedback from confirmatory exams to develop slightly different grading criteria. Our programs are unique in that in each, a statewide program functions with one consistent interpretation center. The United States has 19.6 million children aged 1 to 5 years; Alaska and Tennessee combined have only 2.2% of them.

The Polaroid-based MTI photoscreener has set a great standard for reliability, simplicity and ability to focus in the dark. New objective technology addresses issues of fixation (33,34), expense and availability (35), and on site interpretation (36,37). We believe the validity and cost of MTI photoscreening, depending on interpretation and validation criteria, is still comparable to remote autorefraction with the Suresight (Welch Allyn, Skanaeteles, New York) (37-39) for screeening.

Photoscreening is considered cost-effective (40) and has about twice the value of widespread preschool comprehensive examinations (30,31). The Charities involved in our studies contributed an incremental cost of about $10 per Alaskan child screened (31), and about $4 per Tennessee screened children after the Coordinating center was set up (41).

CONCLUSIONS

We applaud the contributions and efforts of our local charities, specifically the Lions Clubs and also the public health nurses. Many amblyopic children in our states have been detected at a young age such that thorough therapy should be able to eliminate or substantially reduce amblyopia in our states. However, many (in fact, most) children were not yet reached by this charitable, cooperative approach.

We are encouraged that a level III emerging technology CPT code (0065T) is now available for primary care doctors and health clinics to bill for photoscreening in addition to CPT code 99173 for deliberate monocular visual acuity screening as a part of ongoing pediatric vision screening.

Our sincere hope is that even better photoscreeners will soon be available that can provide more rapid, on site interpretations, so that amblyopic American children can be detected early and directed to appropriate therapy to significantly reduce amblyopia in America and, then, in the rest of the world.

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